Segmented MEMS Mirror Arrays

Mirror Technology Days 2006

Kirtland AFB

NASA Phase II SBIR Contract # NNC05CA21C

Agenda

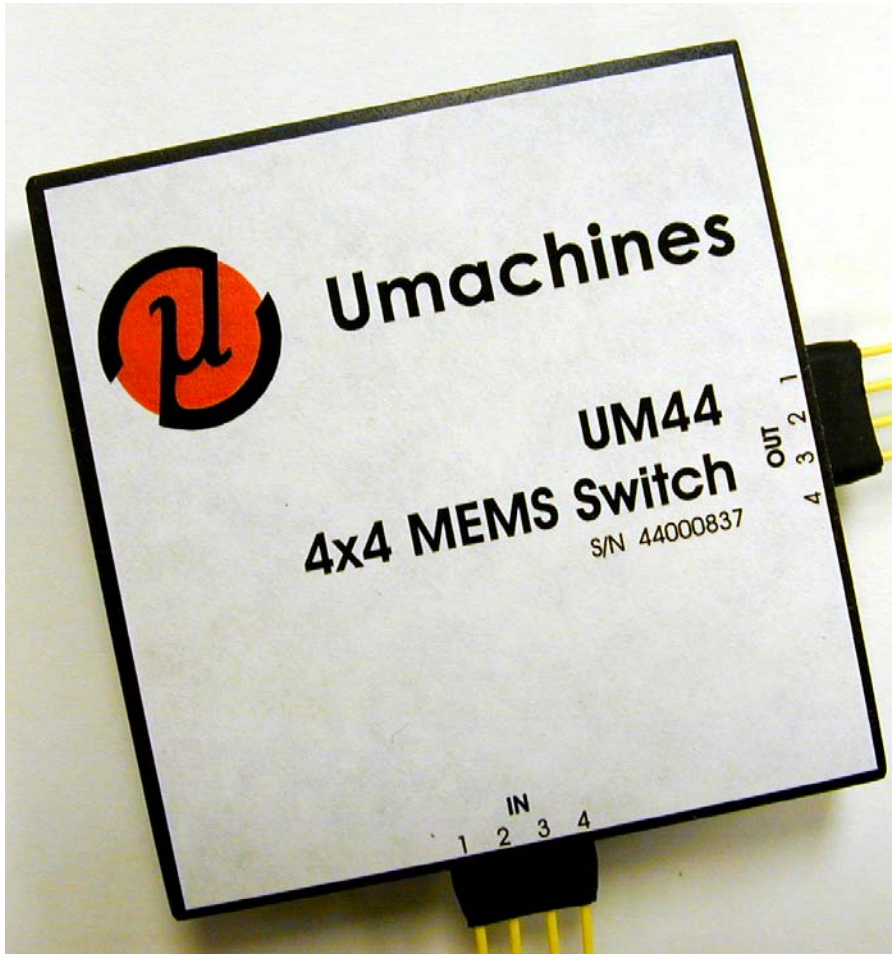
- Umachines background
- High level approach
- Device results

Umachines History

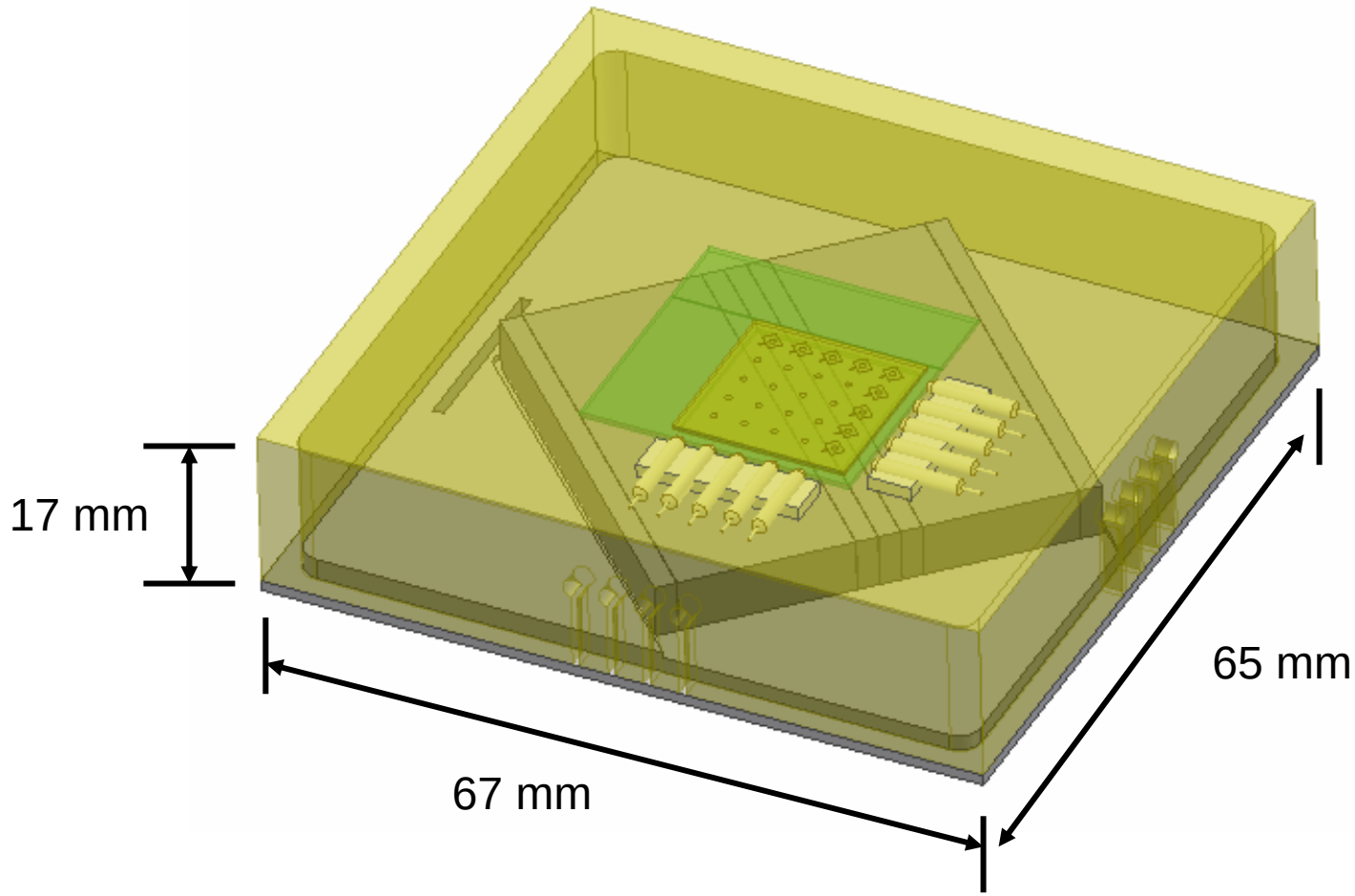
- 1997 – 1999: flow sensors
- 1999 – 2003: optical switch for telecom
- 2003 – 2006: adaptive optics

- Capabilities:
  - Design, Fabrication (Caltech/UCLA), Test
- Outsource:
  - Mechanical Packaging, Electronics

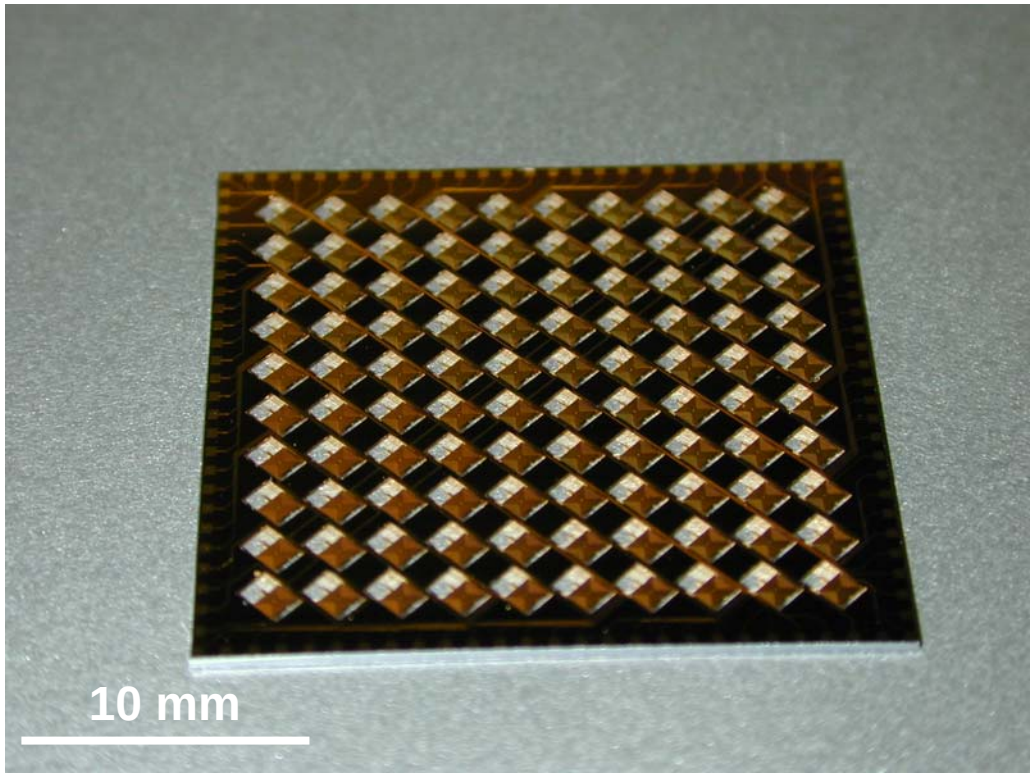
Optical Switch



Optical Switch



Optical Switch Pictures

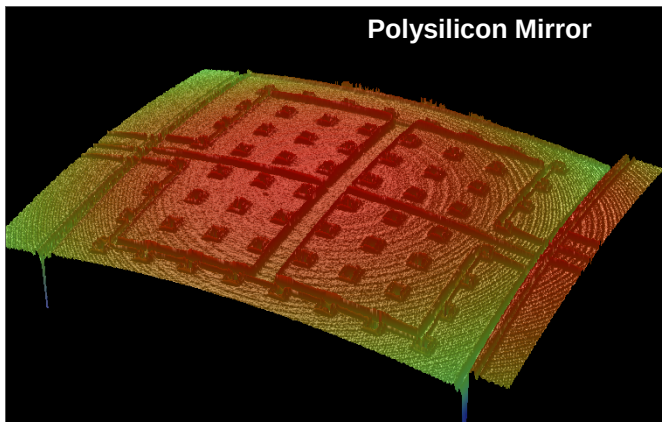


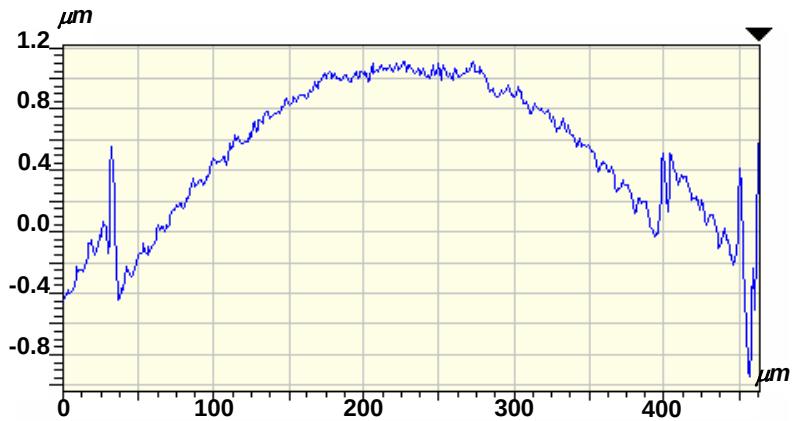
Optical Switch

- VC funded effort
  - Takes a lot of $$$ to develop a product
- Greatest technical accomplishment
  - Telcordia qualification – difference between lab curiosity and product
- Many technical lessons learned
  - Can be applied to other optical MEMS devices

Switch -> Mirror

- Single crystal vs polysilicon for mirror structural material (Wu, Su - UCLA)
  - Competitor lesson





Switch -> Mirror

- Design for reliability
  - If the MEMS can take the pressure…
  - Thermal symmetry

Switch -> Mirror

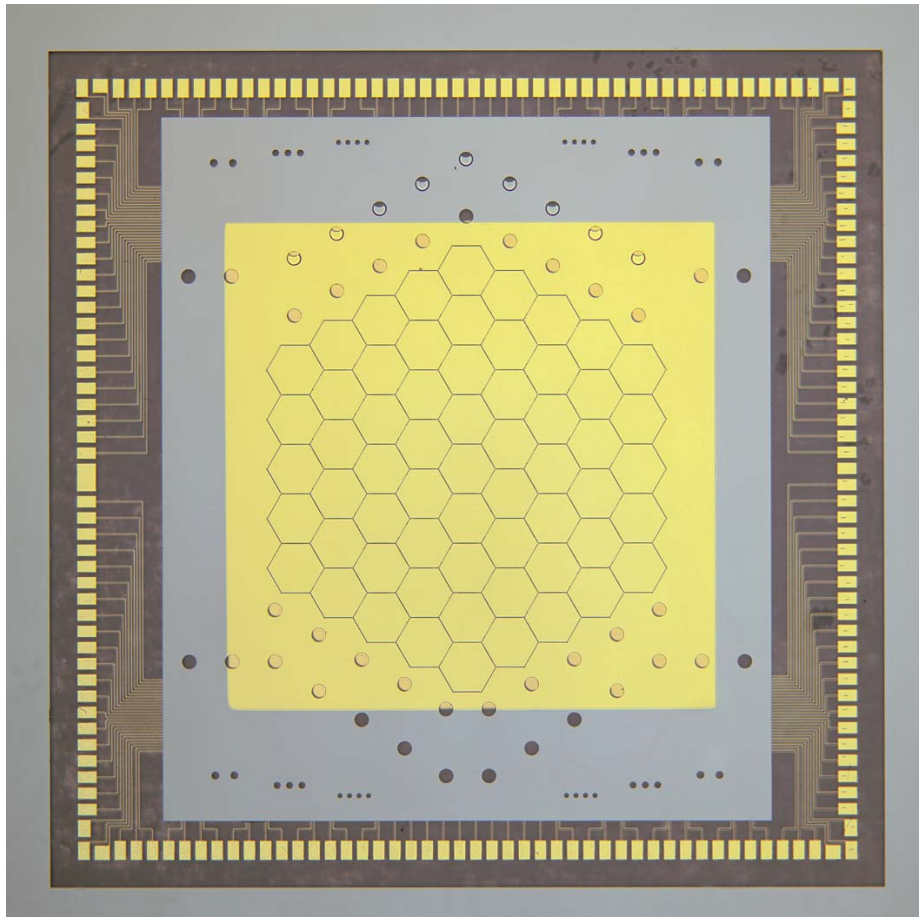
- Design for manufacturing
  - IC cost structure is often used as example, but volumes are required
  - If MEMS are mass produced, but packaging is serial, big problem

Lesson Applications

- Use single crystal silicon as mirror material
- Use symmetric mechanical designs wherever possible
- Design for packaging (think about electrical leads required for large port count devices)

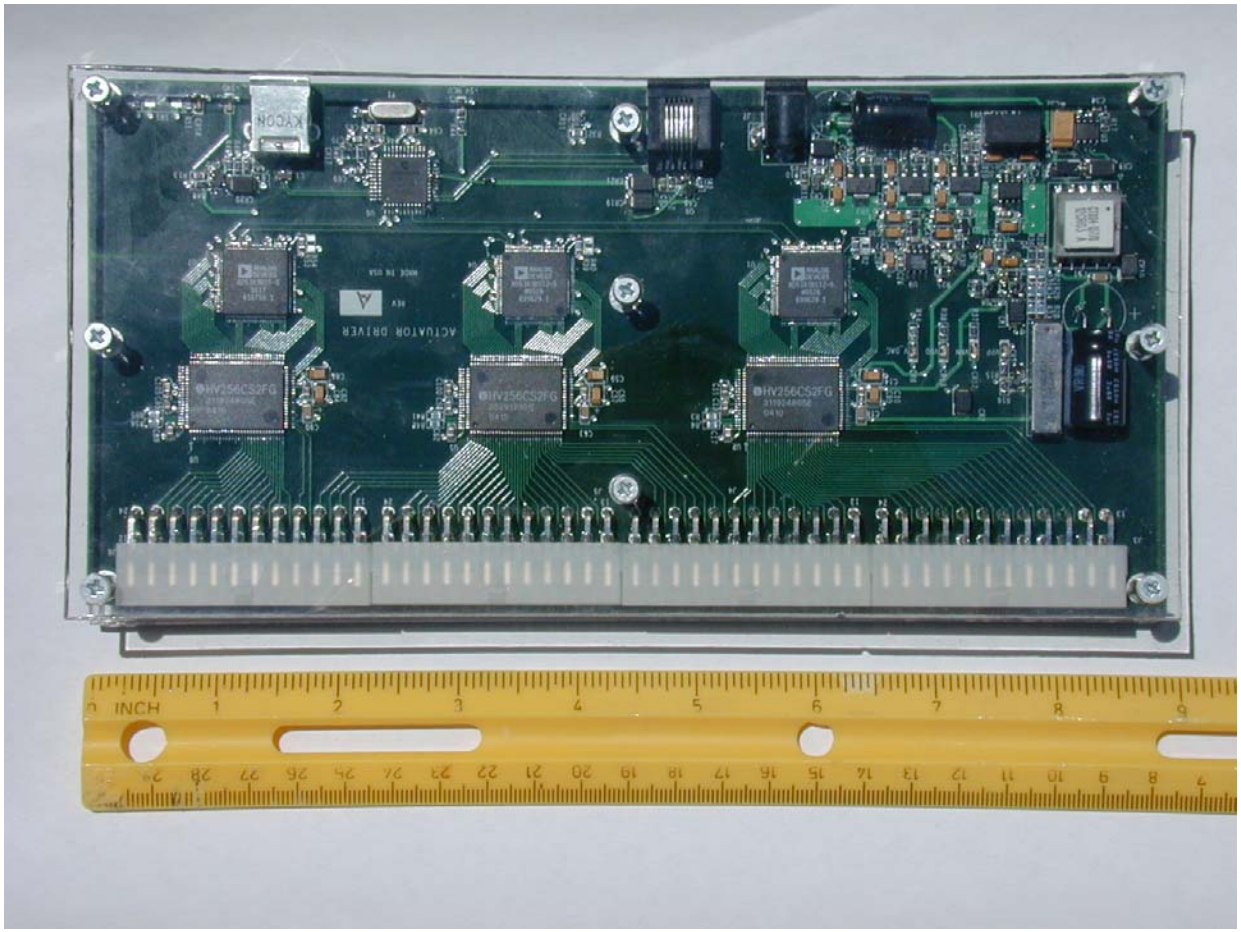
Current Results

61 Element Array

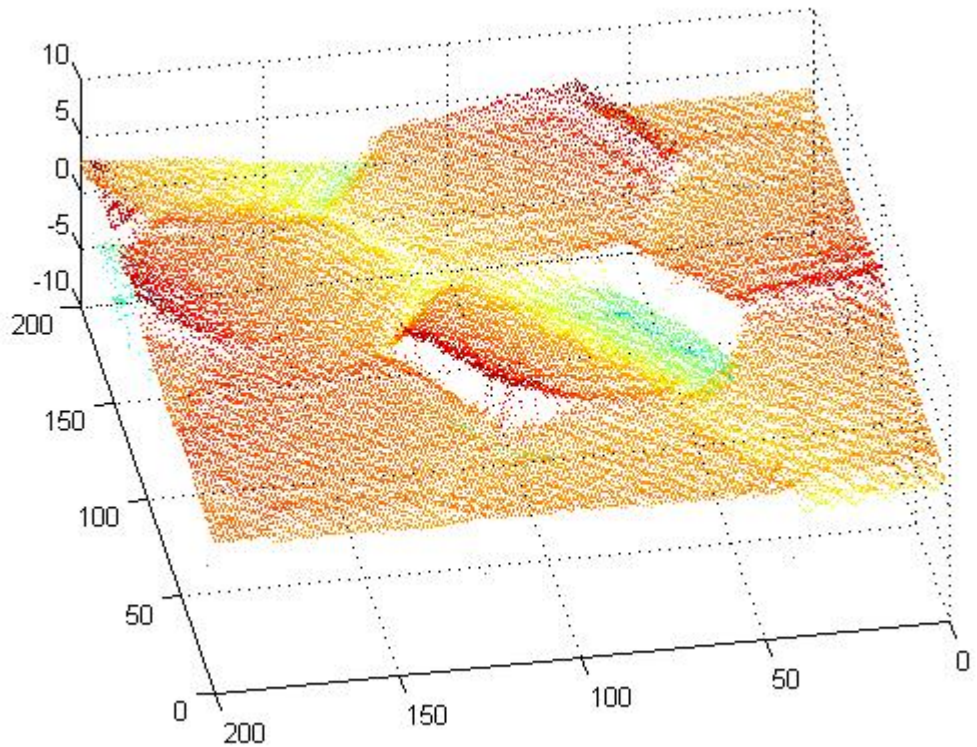


1 cm

80-Ch Driver

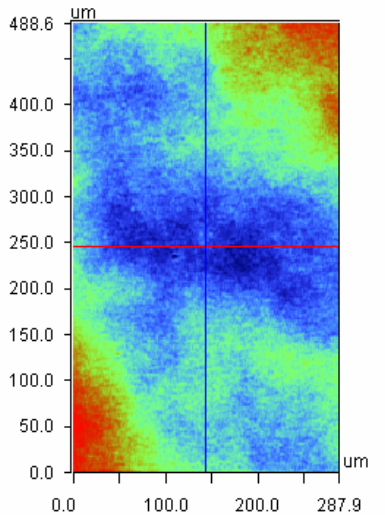


Optical Results



4-bin PSI Image (Mansell)

Surface Quality



X	142.32	-	um
Y	245.27	-	um
Ht	-2.10	-	nm
Dist		-	um
Angle		-	°

Title: Subregion

Note: X offset:65 Y offset:27

X Profile

Rq	0.76	nm
Ra	0.56	nm
Rt	4.19	nm
Rp	0.50	nm
Rv	-3.70	nm

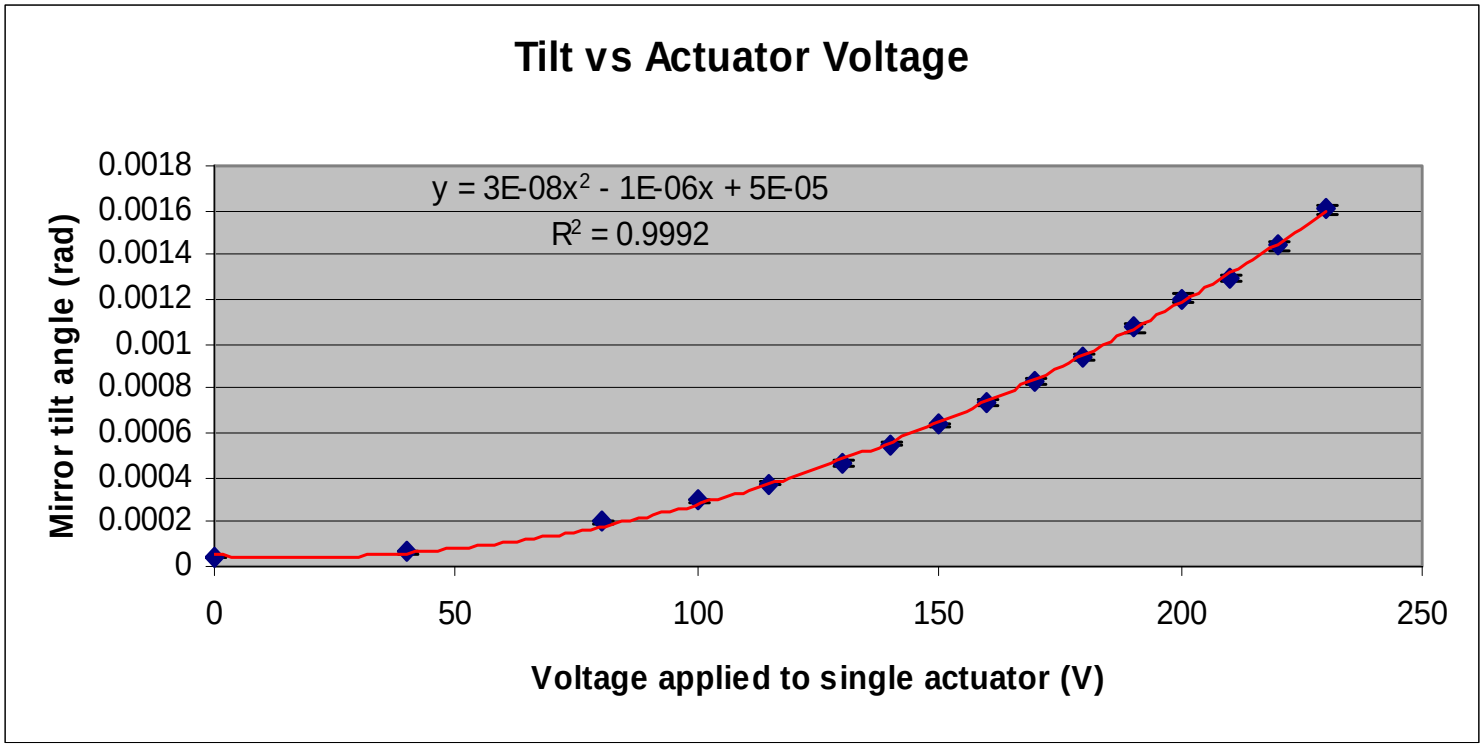
Angle	-4.84	urad
Curve	5.46	m
Terms	None	
Avg Ht	-2.04	nm
Area	-0.59	um2

Y Profile

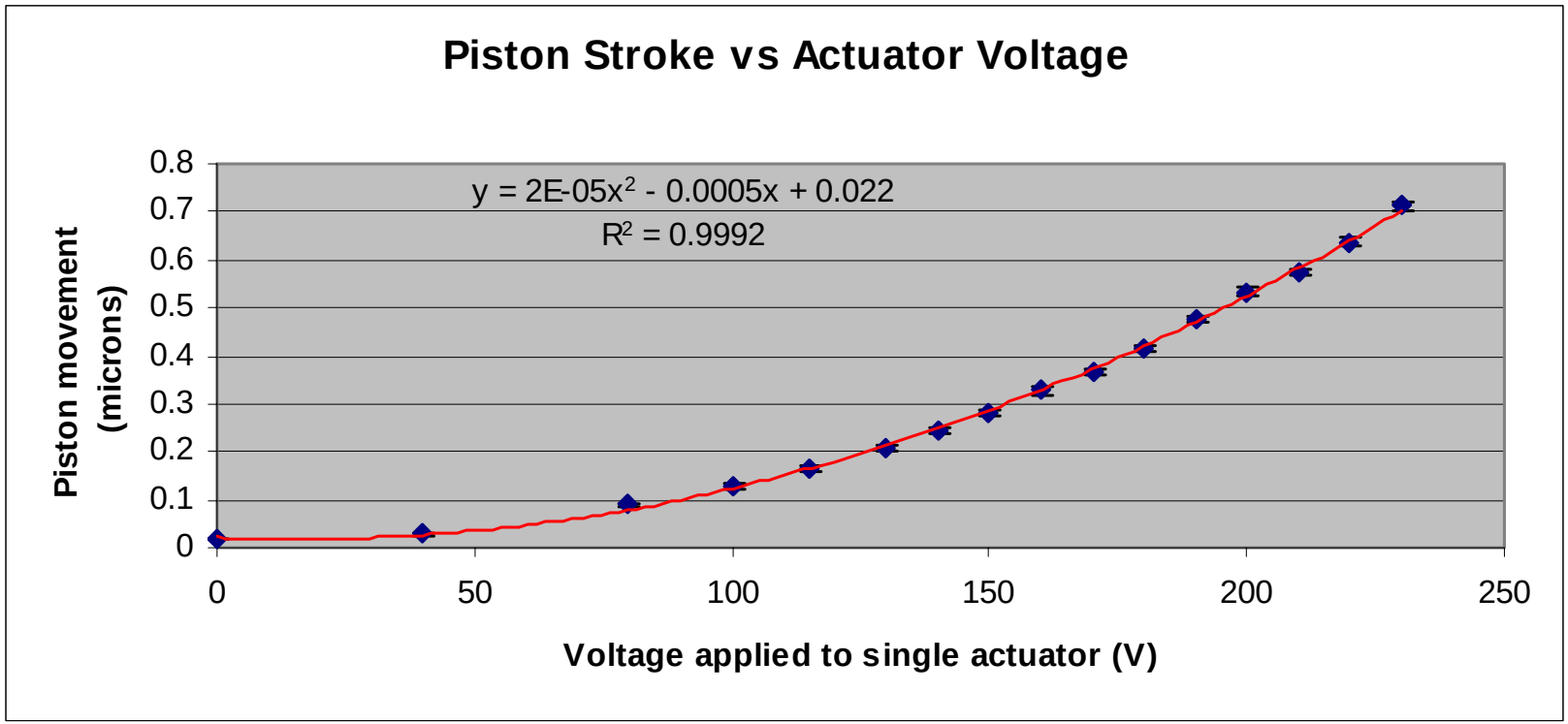
Rq	1.01	nm
Ra	0.82	nm
Rt	4.62	nm
Rp	1.82	nm
Rv	-2.80	nm

Angle	-0.53	urad
Curve	13.20	m
Terms	None	
Avg Ht	-0.39	nm
Area	-0.19	um2

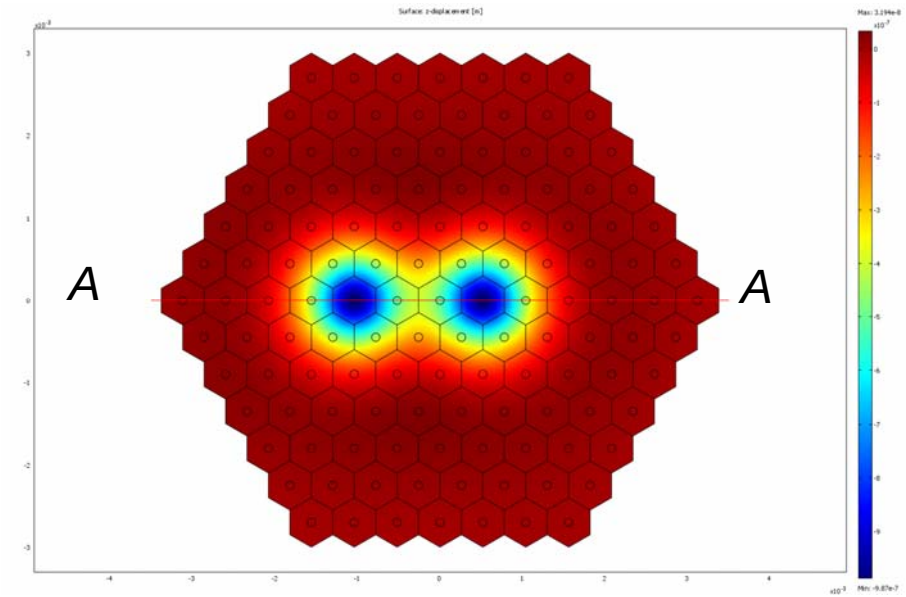
Mechanical Test Results



Mechanical Test Results



Continuous Membrane Simulation



Displacement along *A-A*